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Potential risks to ring-necked pheasants in California agricultural areas using zinc phosphide

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Abstract

Both wild-caught (32) and pen-reared (29) ring-necked pheasants (*Phasianus colchicus*) were studied using radio-telemetry in agricultural areas including: milo (sorghum — *Sorghum vulgare*), rice (*Oryza sativa*), corn (*Zea mays*), alfalfa (*Medicago sativa*), melon (*Cucumis melo*), and weeds. Following capture, demographic data collection, and radio-collaring, they were released into agricultural habitats near Meridian and Nicolaus, CA. After 7 days of acclimation, habitat use and mortality of radio-collared birds were monitored daily using radio-telemetry with Global Positioning Satellites units to record their locations. Randomly selected Meridian alfalfa fields (≈ 160 acres) were treated with 2% zinc phosphide (Zn_3P_2) on steamed rolled oat (SRO) baits for vole control, whereas, Nicolaus alfalfa fields (≈ 160 acres) were treated with placebo baits. After ≈ 5 weeks of radio-tracking during September and October 1996, no pheasants were killed as a result of the Zn_3P_2 baiting. Baits lost substantial potency ($> 30\%$) during their exposure to field conditions after 24 h. Most pheasants died from avian or mammalian predation ($n = 34$, 85%) with pen-reared pheasants more vulnerable to predation than wild pheasants. All mortalities were found in habitats other than alfalfa; upon dissection, they did not have SRO baits (either control or treated) in their gastrointestinal tracts. © 2000 Elsevier Science Ltd. All rights reserved.

1. Introduction

All rodenticides in the US are registered with the US Environmental Protection Agency (EPA). One acute rodenticide, zinc phosphide (Zn_3P_2) (CAS No. 1314-84-7) causes death by cessation of respiration. Its mode of action is the release of phosphine gas (PH_3) during hydrolysis in the gastrointestinal (GI) tract of poisoned animals. It has become a very important tool in the control of jackrabbits (*Lepus* spp.) and prairie dogs (*Cynomys* spp.) on rangeland (Tietjen and Matschke, 1982), nutria (*Myocastor coypus*) in agricultural areas (Evans et al., 1966), rats (*Rattus* spp.) in sugarcane (Doty, 1945; Hilton et al., 1972) and macadamia nuts (Fellows et al., 1978), and voles (*Microtus* spp.) in orchards (Hegdal and Gatz, 1977) and crops (Marsh, 1988). EPA has established tolerances for its

use in several food crops, including sugarcane (Hood, 1972), sugar beets, alfalfa, artichokes, and grapes (Johnson and Fagerstone, 1994).

In the western US, voles cause extensive damage to alfalfa (*Medicago sativa*) (Lewis and O'Brien, 1990) with an estimated US\$8.5 million annual loss in northern CA (Putnam, 1994). Zinc phosphide is currently in the final stages of reregistration by EPA, as required by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended (FIFRA, 1988; Ramey et al., 1994a). In anticipation of the potential data requirements to reregister federal and state registrations for zinc phosphide (FIFRA Section 24 [c]), the California Department of Food and Agriculture (CDFA) sought efficacy and nontarget data for their product (Rodent Bait Zinc Phosphide Treated Grain (2.00%)) (Clark, 1994) using EPA guidance (Fite et al., 1988). The zinc phosphide-treated grain bait is broadcast to control California voles (*M. californicus*) and montane voles (*M. montanus*) in alfalfa. The CA label

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specifies that zinc phosphide baits are to be applied only during the dormant period of the crop (i.e., the fall after the last cutting of alfalfa for the season or during winter).

The California Department of Fish and Game (CDFG) suggested that zinc phosphide use may impact nontarget wildlife, including quail and pheasants, but the actual effect was unknown (CDFG, 1962; Littrell, 1990). Investigating the main concern of CDFG, the potential for direct poisoning of nontarget species, particularly gallinaceous birds, Ramey and Sterner (1995) showed that wing-clipped California quail (*Callipepla californica*) were not killed after exposure to 2% zinc phosphide bait broadcast for vole control in 0.2 ha (0.5 acre) alfalfa enclosures during the subsequent 20 days post-baiting. However, in the same study, pen-reared, wing-clipped, ring-necked pheasants (*Phasianus colchicus*) sustained 69% mortality during the first 24 h following baiting but none during the subsequent 19 days of study. In these enclosure studies, the pheasants died following continual exposure to the bait, while using the alfalfa for both foraging and cover. In contrast, free-ranging pheasants use alfalfa primarily for cover and not foraging being grainivorous; therefore, they may not have significant exposure to the Zn_3P_2 baits. However, free-ranging pheasants in CA include both wild and pen-reared birds. CDFG supports the many private pheasant clubs that release over 300,000 pen-reared pheasants annually just prior to the fall hunting season (Hart, 1990). Secondary poisoning with zinc phosphide was not of concern to CDFG and CDFA, because zinc phosphide is not accumulated in muscle tissues, and it decomposes rapidly in the GI tract of poisoned animals (Evans, 1967; Savarie, 1981). Additionally, zinc phosphide degrades in the environment when exposed to wet conditions (Breyer et al., 1973), and its toxicity decreases (Hayne, 1951; Ramey et al., 1994b). The primary objective of this study was to provide field nontarget hazard data concerning the potential risk to wild and pen-reared ring-necked pheasants in an operational vole control program in alfalfa using 2% zinc phosphide baits after the last fall harvest. A secondary objective was to compare the natural and zinc-phosphide-related mortality rates of wild versus pen-reared pheasants.

2. Materials and methods

2.1. Study sites

The study was conducted in the Sacramento Valley, near two towns (study sites) in Sutter County, CA (≈ 45 km apart). These areas have some of the highest pheasant population densities in the state (> 0.5 pheas-

sant/acre, Hart, 1990) and abundant alfalfa (Putnam, 1994). One site (≈ 2000 ha) was located southeast of Meridian adjacent to the Sacramento River where the predominant land use was for the cultivation of rice, corn, milo, and alfalfa intermixed with a few walnut (*Jugulans* spp.) orchards and Asian persimmon (*Diospyros* spp.). The second ≈ 2000 ha site, located southwest of Nicolaus on the Feather River, was used for mixed crop production, mainly rice, sugar beets, alfalfa, corn, and safflower, and some walnut orchards. Randomly selected alfalfa fields at the Meridian site were treated with 2% Zn_3P_2 and similarly selected Nicolaus fields were used as untreated controls (placebo). The topography of both sites was essentially in level with a gradual drainage to the south. Both areas contained numerous deep (1–3 m) irrigation and drainage ditches in which cattails (*Typha* spp.), blackberries (*Rubus* spp.), weeds and wild grasses sometimes formed rank growths. Pheasants were found in crop fields, weeds and ditches.

The study began in early September, before the next to last alfalfa harvest, and continued through the first week of November, 1996. Alfalfa was cut, dried, and baled for the last time for the season from 20 to 30 October. Beans were harvested during the last week in September. Rice was harvested during the first 3 weeks in October, and corn was harvested during the last 3 weeks. Watermelons (*Citrullus vulgaris*) were harvested throughout October. It was anticipated that these harvest activities would cause more extensive pheasant movements due to the removal of forage and cover; therefore, an airplane was used for telemetry. Some rice fields were burned after harvest; others were left with the rice straw unburned in the fields due to air pollution restrictions.

Sutter County lies ≈ 180 km east of the Pacific Ocean on the leeward side of the Coastal Range. It has a mild climate that is characterized by hot, arid summers, and wet fall, winter, and spring seasons. Fields are irrigated from the Sacramento and Feather Rivers, which are bordered with tall levees to minimize periodic flooding. During the radio-tracking (11 September–8 November), air temperature and precipitation were measured daily at the Colusa County weather station. Mean (\pm SD) maximum and minimum air temperatures were 25°C ($\pm 6.2^\circ$) and 9.2°C ($\pm 3.4^\circ$), respectively. Precipitation during the study totaled 3 cm (1.2 in.), all in October.

Common predators observed in the Meridian and Nicolaus study areas were: red-tailed hawks (*Buteo jamaicensis*); northern harriers (*Circus hudsonicus*); barn owls (*Tyto alba*); red and gray foxes (*Vulpes fulva* and *Urocyon cinereoargenteus*); coyotes (*Canis latrans*); skunks (*Mephitis* spp.); feral cats (*Felis catus*); and dogs (*Canis familiaris*). Avian species seen in the fields and ditches were meadowlarks (*Sturnella*

neglecta), starlings (*Sturnus vulgaris*), killdeer (*Charadrius vociferus*), blackbirds (*Agelaius* spp.), great blue herons (*Ardea herodias*), and American egrets (*Casmerodius egretta*). A covey of California quail (≈ 12) was observed near Nicolaus.

2.2. Baits and baiting

The 2% Zn_3P_2 steam-rolled oat (SRO) baits were prepared according to the Confidential Statement of Formula (CSF) (CA Reg. No. 10965-50015-ZA and SLN No. CA 890027) in the Bait Formulation Section of the Yolo County Agricultural Commissioner's Office. SRO groats were the carrier (base bait) material, lecithin-mineral oil was the adhesive, and lamp-black was added as a dye. Placebo bait contained all the ingredients in the 2% Zn_3P_2 treated bait, except Zn_3P_2 .

Placebo bait totaling 680 kg (1500 lb) and 794 kg (1750 lb) of 2% Zn_3P_2 treated bait were purchased and received on 22 October, packaged in 22.7 kg (50 lb) bags. The treated bait was stored in a locked pesticide storage facility. Bait samples (≈ 250 g) were taken from the placebo and zinc phosphide bait bags as they were opened on 24 October and 1 November, respectively. The samples were frozen and sent to the National Wildlife Research Center (NWRC) for chemical analysis using a phosphine (PH_3) headspace analysis procedure (NWRC Validated Method No. 29A). Also, ≈ 250 g of each bait was removed from freshly-opened bags on November 1, 1996 and were placed into a 30.5 cm \times 61 cm (1 \times 2 ft) wooden-framed enclosure in an alfalfa field and protected from animals by covering it with 1 in. mesh chicken wire. Samples weighing between 30 and 50 g were removed daily (≈ 1750) for 5 days (2–6 November) and placed in labeled plastic bags, frozen, and sent in a cooler with dry ice to NWRC on 8 November, for comparative analysis. The weather from 1 to 6 November, consisted of several mornings with dense fog and cool daytime high temperatures 4.4–10°C (40–50°F). It was windy on days when fog was absent.

Untreated alfalfa control fields near Meridian and treated alfalfa fields near Nicolaus were randomly selected for pheasant activity studies several weeks prior to baiting. They were ≈ 45 km apart. At each site, alfalfa fields totaling 64.8 ha (160 acres) in size were randomly chosen from ≈ 812 ha (2000 acres) of alfalfa.

Both untreated placebo and zinc phosphide-treated SRO baits were applied by Certified Pesticide Applicators (CPA) from the Contra Costa County Agricultural Commissioner's Office, Concord, CA. Two all-terrain vehicles (ATVs) with rear-mounted bait broadcasters were used for all applications. The amount of bait per m^2 was calibrated before application by

repeated runs broadcasting placebo baits on asphalt roads, where bait particles could be readily seen and counted. Calibration of the number of steam-rolled oat groats was determined in 0.09 m^2 (1 ft^2) quadrat frames, placed at the center of the road and counts were made every other foot extending outward from the center of the road for 3.05 m (10 ft) on each side. The amount of bait/ m^2 and speed of the ATVs were held constant to determine by trial and error the appropriate application rate of SRO groats of 25.6 m^2 (2.3/ ft^2). The best baiting swath width was determined to be 6.1 m (20 ft) for even coverage. An ≈ 31 m (100 ft) border strip along the perimeter of each alfalfa field was determined and marked with small plastic flags at ≈ 6.1 m (20 ft) intervals. These border strips were to remain unbaited as per label directions. The flags placed at 6.1 m (20 ft) intervals along the exterior on two opposite sides of the fields were used to facilitate baiting by the CPA applicators on ATVs. They alternated, driving back and forth on an imaginary line between the flags broadcasting the bait. Following baiting, the flags were removed except the corner flags for referencing the buffer. Baiting was done on these fields within days following the final fall cutting, drying, and baling of the hay. Prebaiting although recommended on the label was not done, because the cooperators had not planned to prebait due to its high cost and lack of a proven increase in efficacy. The placebo bait was applied at Nicolaus on 24 and 25 October, at the rate of 11.2 kg/ha (10 lb/acre). The zinc phosphide-treated bait was applied at Meridian on 31 October and 1 November, at the same rate.

2.3. Instrumentation and capture

The radio-transmitters used were built by Advanced Telemetry Systems (ATS) (470 First Avenue, Isanti, MN 55040). They were a neck pendant attachment design (necklace transmitters-205) with a weight of 12 g. The broadcast frequency was from 164.4375 to 167.1575 MHz. The normal operating pulse rates were 60 or 90 pulses per minute (ppm), with a mortality mode of 150 ppm that activated after 1 h of inactivity. The receivers used were ATS and Custom Electronics (2009 Silver Court West, Urbana, IL 61801). Vehicles were equipped with dual beam, 3-element Yagi antennas. An airplane prepared for radio-tracking was used to locate "lost" pheasants.

Spotlighting, a proven successful and efficient method for capturing wild pheasants under CA conditions (Hart, 1990), was used. Birds were captured using an Argo 8-wheel all-terrain vehicle or two ATVs using 1 million candle-power spotlights to locate pheasants. Few indigenous pheasants were seen or captured in alfalfa, particularly in alfalfa stubble. Thus, only four wild hens were captured in alfalfa, none in stub-

ble (in 270 min of trapping effort), four in windrows (in 565 min), and one recaptured later in the study in 38.1–45.7 cm tall (15–18 in.) alfalfa (in 320 min). Two wild hen pheasants were caught in Meridian windrows and two hens were caught in Nicolaus windrows. As the alfalfa grew taller (i.e., became better cover), more pheasants used the alfalfa but additional trapping was not allowed by cooperators because of the probable significant loss of alfalfa hay revenues from the use of the Argo or ATVs in the fields. Because of the insufficient number of pheasants observed or captured in the alfalfa fields ($n = 4$), other areas surrounding the alfalfa study sites were trapped (mainly weeds along the canals and fence lines) with no success. However, many pheasants were seen but they always flew or ran into the dense crops to escape capture. Other crops were also not trapped because of the potential for economic loss from the use of the ATVs in rice, milo and corn fields prior to harvest. Thus, additional wild pheasants had to be captured at night from weedy areas near the Yolo County landfill between the cities of Woodland and Davis, CA, and from annual grasslands with weeds at the Hill Slough State Wildlife Management Area near Suisun City. These captured pheasants ($n = 28$) had to be relocated and had ≈ 4 weeks to acclimate to their new surroundings before baiting commenced.

The overall capture rate for pheasants in alfalfa was one bird for 289 min of searching, whereas the capture rate in weeds was one bird for every 19 min of searching. After capture, pheasants were sexed and weighed, then fitted with radio-collars and leg bands, each with a unique number (National Band and Tag, Newport, KT). All pheasants radio-collared during the study weighed > 625 g. The 12 g radio-transmitter represented $\approx 1.9\%$ of the smallest pheasant's weight. Radio-collared birds were put into CDFG wooden pheasant crates, on the back of the ATVs, for immediate transport to their capture location in the alfalfa fields for release ($n = 4$). Twenty-eight other relocated pheasants were transported in CDFG wooden pheasant crates to either the Meridian or Nicolaus study areas using a pickup truck. The relocated pheasants were released along the edges of alfalfa fields with at least two other crops or weeds available for their choice of habitat. All relocations were done on the same night as their capture. By this method, 14 relocated pheasants (10 hens and four roosters) were released at Meridian on 18 and 19 September, and 14 birds (nine hens and five roosters) were released at Nicolaus on 13, 15, 18 and 23 September.

Pen-reared adult pheasants raised for hunting clubs release were purchased from a local pheasant producer on 11 and 12 October, prior to the hunting season. They wore straight-ahead, sight-blocking goggles on their bills, designed to keep the birds from pecking

each other. The goggles were removed by the breeder at the time the birds were captured for transport to the study sites ($\approx 8:00$ a.m.). Immediately before release ($\approx 9:00$ a.m.– $11:00$ a.m.), these pen-reared birds were weighed, banded, and radio-collared. Sixteen pheasants (nine hens and seven roosters) were released at alfalfa field edges with at least two other habitat types available at Meridian on 11 October, and 13 birds (seven hens and six roosters) were released at similar alfalfa field edges at Nicolaus on 12 October. These pen-reared birds were released about 3 weeks later than wild-caught birds due to their predicted higher mortality, about 10 days before baiting.

2.4. Radio-tracking

Tracking stations, where vehicles were positioned for triangulation, were placed at field edges using a Trimble GeoExplorer GPS instrument, with ≈ 2 m accuracy. Each tracking station was identified with a numbered flag. Before locating the radio signals, the vehicle was oriented to point north using a compass mounted on the roof inside the vehicle. The compass was regularly checked for accuracy at the local airport where there was a ground compass rose. When first locating a bird, the peak signal was used; then the null signal was used before the bearing was recorded. All data were documented on individual data sheets for each pheasant and entered into a portable laptop computer. The observation number, date, time, station number, bearing from the station, and habitat were recorded.

Pheasants were located at least once each day. At least two bearings were used to locate each bird, with extra effort taken to position the vehicle at $\approx 90^\circ$ angles from the transmitters. Whenever the pheasants were located in large crop fields, three or more bearings were taken, to minimize the error polygon generated by the LOCATE II (1990 version) computer program (Pacer, Box 1767 Truro, Nova Scotia, Canada B2N 5Z5). Error polygons ranged from 3 to 38,863 m², with a mean of 2845 m² (± 922 SE) at Meridian and 4500 m² (± 2013 SE) at Nicolaus. After locating each bird each day, its readings were entered into the LOCATE II program and the recorded location was confirmed. Computer-generated maps were printed with the locations of all pheasants at each study site each day so they could be more easily located the following day. Radio-telemetry data were analyzed daily as described by Pollock et al. (1989). An observation was censored by the LOCATE II program because of radio failure or because the individual survived beyond the period of interest. The analysis required three basic assumptions: (1) survival times are independent among the different individuals; (2) the censoring mechanism

is random; and (3) a random, unbiased sample of animals is obtained.

2.5. Carcass searches

Carcass searches for dead animals were carried out daily on both the placebo and treated alfalfa fields starting the day of baiting. Two ATVs were driven by the observers at average speeds of 10–16 km/h (6–10 mph) on transects ≈ 6 m (20 ft) apart on parallel courses on each alfalfa field. Dead animals, including old carcasses apparently killed or scavenged by predators before treatment, were recovered. Fresh animal carcasses were kept frozen until necropsied and examined for the presence of either bait. To test the ability of the observers to locate carcasses, three pheasant carcasses (mortalities that had occurred pretreatment) were placed in the alfalfa fields at locations unknown to the observers, and these three carcasses were found.

3. Results and discussion

Replicate analyses of the test bait sampled from the bags on the day of treatment yielded a mean value of 2.1% Zn_3P_2 (± 0.3 SD). Zinc phosphide was not detected in control (placebo) baits. The environmentally exposed 2.1% Zn_3P_2 treated bait after 1 day showed a total loss of $\approx 33\%$ of active ingredient to 1.4% (± 0.21 SD), which was similar to the 37% loss of Zn_3P_2 after 24 h reported by Ramey and Sterner (1995). Over the next several days of exposure, only a slight additional decrease (nonsignificant) in concentration was detected, despite the foggy and wet conditions encountered in the field. The treated grains did not seem to swell from moisture as observed in the work of Sterner and Ramey (1995).

Dead animals including predator-kills and remains of carcasses that recovered pretreatment, included parts of five pheasants, three egrets, two jackrabbits, and a toad (crushed by harvesting machinery). Post-treatment in treated fields, five passerines were found during the 6 days after treatment. These birds were not chemically analyzed for zinc phosphide residues because of the lack of a validated analytical method for these species, but instead were examined by necropsy for evidence of SRO groat bait in their GI tracts and particularly their stomachs. Examination of the five birds revealed that two of the three meadowlarks had remnants of SRO groats along with cricket parts in their stomachs. The other meadowlark contained only parts of crickets. The two dead American pipits (*Anthus rubescens*) had empty stomachs. Death from zinc phosphide would likely occur in passerines within a few hours after eating poisoned oats, and poisoned grain would be found in their stomachs. Two of

the three meadowlarks found dead had bait remnants and probably died from zinc phosphide poisoning, but the cause of death for the other meadowlark was unknown. Because pipits are primarily insectivorous (Verbeek and Hendricks, 1994) and had empty stomachs, their deaths were assumed to be from other causes.

Live birds seen in the placebo and treated fields during the carcass searches were flocks of >100 European starlings and blackbirds, dozens of meadowlarks and pipits, small groups of 5–10 killdeer, and a few common egrets. The fields contained numerous spiders and countless field crickets, which may have attracted some of the birds. Pretreatment and posttreatment carcasses of radio-collared pheasants were collected the first day after death.

3.1. Pheasant mortality at the treated (Meridian) site

No pheasants were killed as a result of the zinc phosphide baiting, although other types of mortality did occur. During the entire study (pretreatment and posttreatment) at Meridian (≈ 50 days from 18 September instrumentation of the first pheasants until the posttreatment follow-up on 6 November), 15 pheasants (four wild-relocated and 11 pen-reared) were found dead of the original 32 instrumented (16 wild and 16 pen-reared). Of the 15 pheasants, 13 died pretreatment (18 September–30 October), the cause of death for 10 was concluded to be from avian or mammalian predators, and one each from harvesting operations, poaching by hunters, and unknown causes (only the radio-transmitter was found). Following treatment of the alfalfa fields with zinc phosphide baits on 31 October and 1 November, two pen-reared birds were killed by predators; both were found at least 1 km distance from the treated alfalfa fields. Both birds had been observed at random daily times only in milo fields for periods of 18–38 days, and one rooster was poached by human predator/hunter before the season started and found skinned in a pumphouse, and the other rooster was killed by an unknown predator and was found in a ditch.

3.2. Pheasant mortality at the placebo (Nicolaus) site

During the entire study (pretreatment and posttreatment) at Nicolaus (55 days from 13 September to 6 November), 12 pheasants were found dead (three wild-relocated and nine pen-reared) of the original 29 released (16 wild and 13 pen-reared). Ten pheasants died pretreatment, victims of avian and mammalian predation. Two pen-reared pheasants died following the placebo-baitings on 24 and 25 October, both due to predators. Of the two birds found dead following placebo baiting, one hen died in a safflower field and

one rooster in a ditch. Comparison of pretreatment and posttreatment pheasant mortalities at Meridian and Nicolaus revealed a similar pattern, with 13 dying pretreatment and two posttreatment (in 7 days) at Meridian, and 10 dying pretreatment and two posttreatment (in 13 days) at Nicolaus. All four posttreatment mortalities were pen-reared birds.

3.3. Comparison of survival of wild and pen-reared pheasants

Mortality was higher for pen-reared than for wild pheasants. At Meridian, four (all relocated) wild pheasants died (25%), while 11 (69%) of the pen-reared pheasants died. The survival rates at 4 weeks were lower for pen-reared pheasants (28%) than for wild pheasants (68%). At Nicolaus, three (all relocated) wild pheasants (19%) and nine pen-reared pheasants (69%) died. Survival rates at Nicolaus at 4 weeks, again as expected, were lower for pen-reared (29%) than for wild pheasants (74%). The pen-reared pheasants were more vulnerable to predators, especially the avian predators, than the wild pheasants. One behavioral difference observed at the time of release was wild pheasants took off immediately, either running or flying into dense cover, while many pen-reared pheasants had literally to be chased into cover and several others flew or ran short distances and remained in open fields or along roadsides. No further attempts were made to haze these pheasants.

The 4-week survival of pen-reared pheasants at both sites is typical of findings of other studies (Hessler et al., 1970; Krauss et al., 1987). Hessler et al. (1970) found that 4 weeks after release, survival of radio-tagged pheasants was only 19%. Mortality was greater during the first 15 days following release than during the later 16–28 days. Krauss et al. (1987) compared survival at 4 weeks for game-farm and wild birds and found that survival averaged 24% in 1982 and 32% in 1983 for game-farm birds after release, while wild birds averaged 72 and 88% at 4 weeks in 1982 and 1983, respectively. They noted that game-farm birds showed a low avoidance behavior to approach by the observer, so may have been more susceptible to predation. In our study, pen-reared birds were naive about suitable cover for protection from avian predators and 40% were lost to predation during the first week, but the rate of loss decreased over time.

3.4. Habitat use

The general patterns of habitat use by both wild and pen-reared pheasants at Meridian were only slightly different. The main documented difference was less use of harvested rice fields by pen-raised pheasants. Overall, slightly more than twice, as many observations

were obtained on wild-caught birds ($n = 546$), because they were released 3 weeks before the pen-reared birds ($n = 269$). Pheasants at Meridian selected habitats in different proportions than their availability during the study. Milo fields, corn fields, and ditches were used more than expected ($P < 0.01$), while rice and fallow fields, and orchards were used less than their availability would indicate ($P < 0.01$). Use of alfalfa fields was proportional to their availability, but use was confined almost entirely to the period just before the alfalfa was harvested (51 observations); only two observations (0.4%) were made following treated bait application in alfalfa stubble after the last cutting. Before cutting, the alfalfa was 30–45 cm in height, and provided good cover for pheasants. After cutting, it was only 7–15 cm in height and pheasants avoid these fields probably because of their vulnerability to predators. Other crops (milo, corn, rice) provided excellent pheasant cover for both foraging and resting during the day before harvest. The ditches were extensively used by pheasants, probably as a source of water, shelter, and foraging cover. Many pheasants were flushed from ditches in the early morning hours.

Pheasant habitat use at Nicolaus was predominantly rice, but less than expected based on its availability ($P < 0.01$). Corn and alfalfa fields, and ditches, were used more than expected ($P < 0.01$), while fallow fields were significantly underutilized ($P < 0.01$). Fields of sugar beets and safflower were used in proportion to their availability. Sudan grass areas appeared to be preferred, while orchards and bean fields appeared to have been avoided, but there were not enough data to confirm these indications. Pheasants seemed to use alfalfa fields when they provided sufficient cover from predators and shelter from the elements, primarily the wind, to be useful. This seemed to occur prior to the alfalfa being cut, baled, and the stubble treated with placebo baits; 125 visits (94%) were made before treatment and eight visits (6%) after placebo treatment. Of the latter, four visits were in the buffer zone and four were in the placebo-treated portion of the fields.

4. Conclusions

The objective of this study was to determine the risk to pheasants from broadcast baiting with 2% zinc phosphide for rodent control in alfalfa fields. No pheasants were killed by zinc phosphide baits, probably because they infrequently used alfalfa stubble fields after the last cutting of the season and subsequent baiting; the majority of pheasants were found in fields of milo, sugar beets, or corn, and in ditches adjoining these fields. Most birds showed habitat fidelity in their choice of milo, rice and corn fields until harvested. Similarly, only 6% of the pheasant locations were in

alfalfa fields following harvest and treatment with either placebo or zinc phosphide-treated baits. Of the 10 observations in the post-harvest alfalfa fields, four were in the buffer zones and six in the actual placebo or zinc phosphide-treated areas. After cutting, the alfalfa was only 7–15 cm in height and was unattractive to pheasants for either foraging or resting cover. Furthermore, the density of broadcast oat groat baits on the ground, about 25.6 grains/m² (2.5 grains/ft²), was apparently insufficient to entice pheasants into harvested alfalfa fields. Because the pheasant radiotelemetry data showed little use of alfalfa fields following baiting (placebo or treated) and no pheasants were killed by poisoned baits, we conclude that there is no risk to pheasants from the application of 2% zinc phosphide baits to control voles following the fall harvest of alfalfa. Also, the use of alfalfa stubble was so infrequent (both buffer and treatment areas) that the buffer areas are probably not needed. Two meadowlark carcasses contained bait in their crops or stomachs, while three other carcasses of passerines (one meadowlark and two pipits) contained no bait material, indicating some bait intake by seed-eating passerines. In relation to the number of passerines observed in and around the alfalfa stubble fields, these numbers are very small and the risk to passerines from this rodenticide use pattern is probably negligible.

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